SANTA CLARA VALLEY WATER DISTRICT

ALAMITOS FISH LADDER
MONITORING REPORT 2003-2004

Project No. 00742011

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December 2004

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I. PROJECT BACKROUND

As part of the planning process for the Alamitos Fish Ladder installation in 1999, the Santa Clara Valley Water District (District) agreed to a five year monitoring period to ensure that fish passage would be afforded at the newly constructed fishway. In previous years, the District would have used an up-migrant weir trap to enumerate adult fish and attempt to establish an abundance index. However, in 1997 steelhead (*Oncorhynchus mykiss*) in the Guadalupe Watershed were federally listed as Threatened under the Endangered Species Act. New regulatory constraints restricted the direct handling of these fish, and therefore, it was necessary to find a means of passively enumerating fish passage through the Alamitos Ladder. District fisheries staff determined that a non-invasive fish counting device placed in the new fishway would satisfy both the monitoring commitment for the fish ladder and the concerns of the Resource Agencies.

In the winter of 2002, District fisheries staff began researching various fish counting strategies and devices available. The most commonly used methods included: manual counting where a person stationed by a window would count and identify each fish which passed, or a video station where a video recorder placed in a watertight housing or stationed at a viewing window would monitor fish passage. Neither of these options seemed feasible to District staff due to the water clarity within the fishway, high degree of nocturnal migration, and the fact that both of these methods are extremely time and labor intensive either directly or upon review of recorded materials. Other, more technologically advanced methods available included: sonar technology which monitors changes in sound waves, and an electrical resistivity counter which monitors differences in charge due to water displacement. Both of these methods seemed improbable due to the large amount of debris and turbulence that are typical of Santa Clara County storm events which would likely yield false positive results. Additionally, neither of these methods would provide enough detailed information to discern the species and size of the fish passing through the fishway.

The last fish counting device considered was the Riverwatcher System (RW) manufactured by Vaki Aquaculture Systems Ltd. in Iceland. The RW is an automated fish counting device which uses infrared light diodes to count passing fish. Data is relayed to an on-site computer where it is stored in a database. The RW system is marketed as being highly efficient, greatly reducing the work and time needed to analyze the data. The RW System is a new device, on the cutting edge of fisheries technology. The RW was chosen by District staff because it seemed to be the most feasible option to meet both the Districts situation and to satisfy the Resource Agencies.

In June of 2003, the District purchased a RW System from PR Aqua, a Canadian supplier of the Vaki product. The District's system was only the 3rd one of its type in use throughout the world. The new Alamitos RW system was anticipated to provide District staff with invaluable information regarding timing, abundance, and diversity of fish species utilizing the ladder. Over the next several years, the information gathered by the RW will improve District staff's understanding of the Guadalupe Watershed fishery.

II. METHODS

On September 19, 2003 District staff installed the new RW fish counting device in the Alamitos Fish Ladder. District staff designed and manufactured a housing which enabled the counting device to fit directly into one of the existing fish ladder panels (Figure 1).

The counter itself is a rectangular shaped unit which is completely submerged within one of the pools in the fish ladder (Figure 2). Fish are directed through the counter opening which is lined with infrared light emitting diodes. When a fish swims through the counter and breaks the plane of light beams, the fish is scanned and a resulting silhouette image is sent to the on-site computer (Figure 3). Other information recorded as the fish passes includes: the speed the fish was traveling, the direction the fish was moving (upstream vs. downstream), the depth of the passing fish (for depth to length ratios), along with the date and time. Fish moving in the upstream direction trigger an underwater black and white video camera which takes up to 5 digital photos of each fish. This enables the user to scan through the images to confirm the presence of a fish and potentially identify the species. All of the data collected by the RW is stored by the attached on-site computer which is powered by two 6 Volt deep cycle batteries that are continually recharged by two 110 watt solar panels.

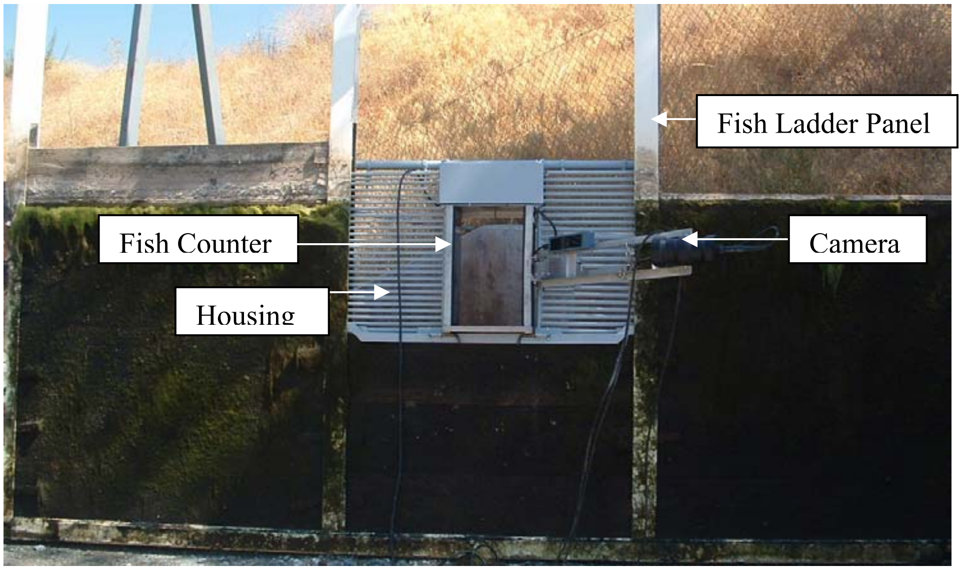

Figure 1. RW fish counter with specialized housing to fit in the ladder.

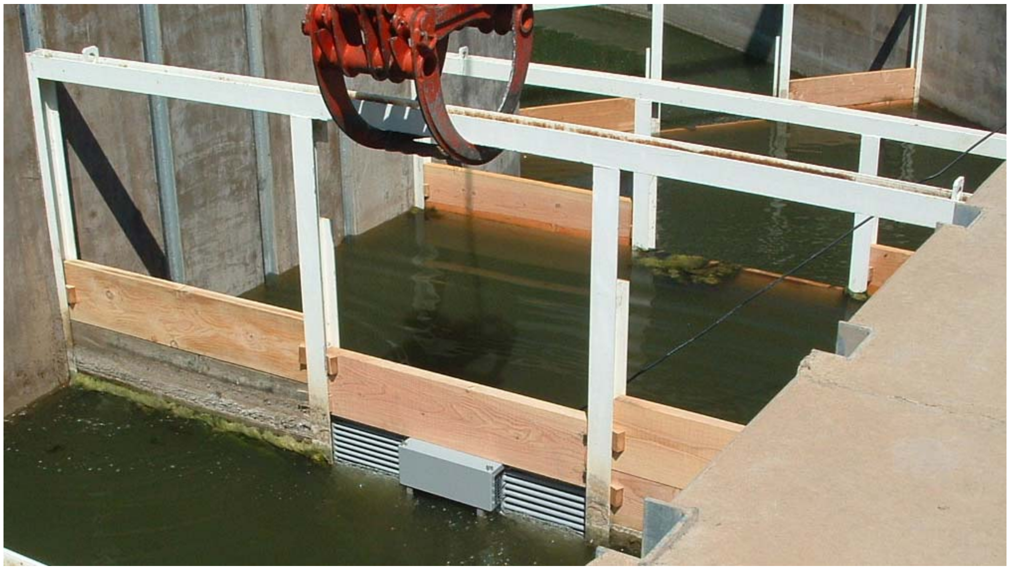

Figure 2. Fish counter installed in the ladder.

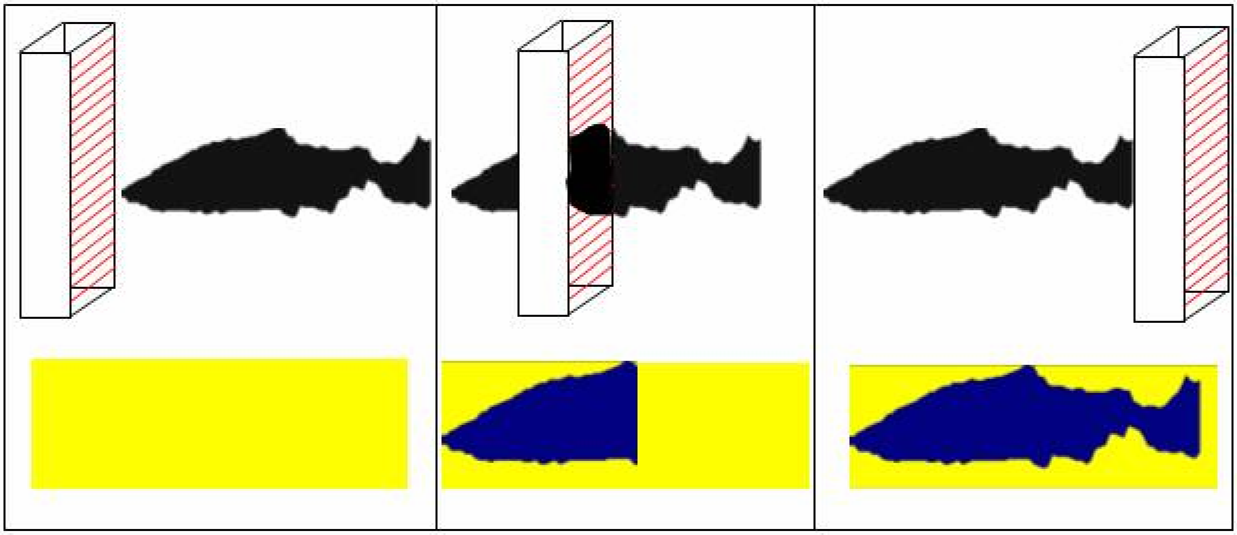

Figure 3. RW scanner function and resulting silhouette.

The counter was maintained daily during the storm season (November – February) and bi-weekly thereafter until it was removed for modifications on July 7, 2004. Typical maintenance included clearing debris build up on the counter, downloading data from the database, and resetting the system.

The counter had numerous problems and obstacles which required several modifications throughout the year. These issues are detailed in the results section.

III. RESULTS

September 2003 – July 2004

From September 19, 2003 through July 7, 2004, over 1763 aquatic animals of various sizes, shapes and species utilized the ladder and moved through the RW fish counter. Species using the ladder included: salmonids (*Oncorhynchus* spp.), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), Sacramento suckers (*Catostomus occidentalis*), red-eared sliders (*Pseudemys scripta*), western pond turtles (*Clemmys marmorata*), bullfrogs (*Rana catesbeiana*), and various species of duck.

Due to the lack of clear photographs produced by the RW system, District staff was not able to differentiate between fall-run Chinook and steelhead/rainbow trout which passed through the RW. Therefore, both species were lumped together and designated as 'salmonids.' District fisheries staff confirmed through silhouette, photographic, and size data analysis that 12 definite salmonids (Fall-run Chinook salmon and/or steelhead/rainbow trout) and an additional 10 fish suspected to be salmonids (likely but not confirmed due to poor silhouette resolution and no good photos) traversed their way up the ladder this past year (Figure 4 & 5). It is likely that these numbers are low since salmonids may have moved upstream during the periods when the counter was non-functional. The migration of salmonids to the upper watershed began on November 10, 2003, just after the first large storm event for the year, and tapered off by the end of January 2004 (Figure 6).

Chinook salmon (*Oncorhynchus tshawytscha*) was positively identified both in the ladder and above the ladder. District and Jones and Stokes fisheries staff subsequently identified 2 live Chinook salmon (1 on Guadalupe Creek and 1 on Alamitos Creek), 4 Chinook salmon carcasses (1 on Guadalupe Creek, 1 on

Alamitos Creek, 1 at the upper end of Lake Almaden, and 1 on the mainstem of Guadalupe River just above the counter), and 5 redds (4 on Guadalupe Creek and 1 on Alamitos Creek) on various tributaries above the fish ladder. During an electrofishing study for a different project during the spring of 2004, District fisheries staff found Chinook young of the year in Calero Creek (April 22, 2004), a tributary of the Guadalupe River above the fish ladder. Steelhead/rainbow trout are thought to have traversed the ladder as well, although there has been no visual confirmation.

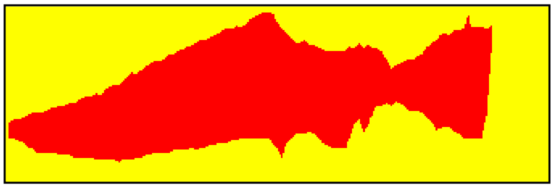

Figure 4. Definite salmonid silhouette from the RW.

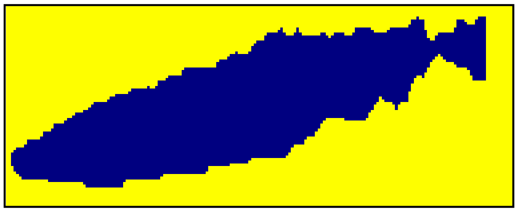

Figure 5. Probable salmonid silhouette from the RW.

(Probable Salmonid = likely to be a salmonid, but not confirmed due to poor resolution of the silhouette. Notice the lack of defined characteristics including the dorsal, anal, and adipose fins)

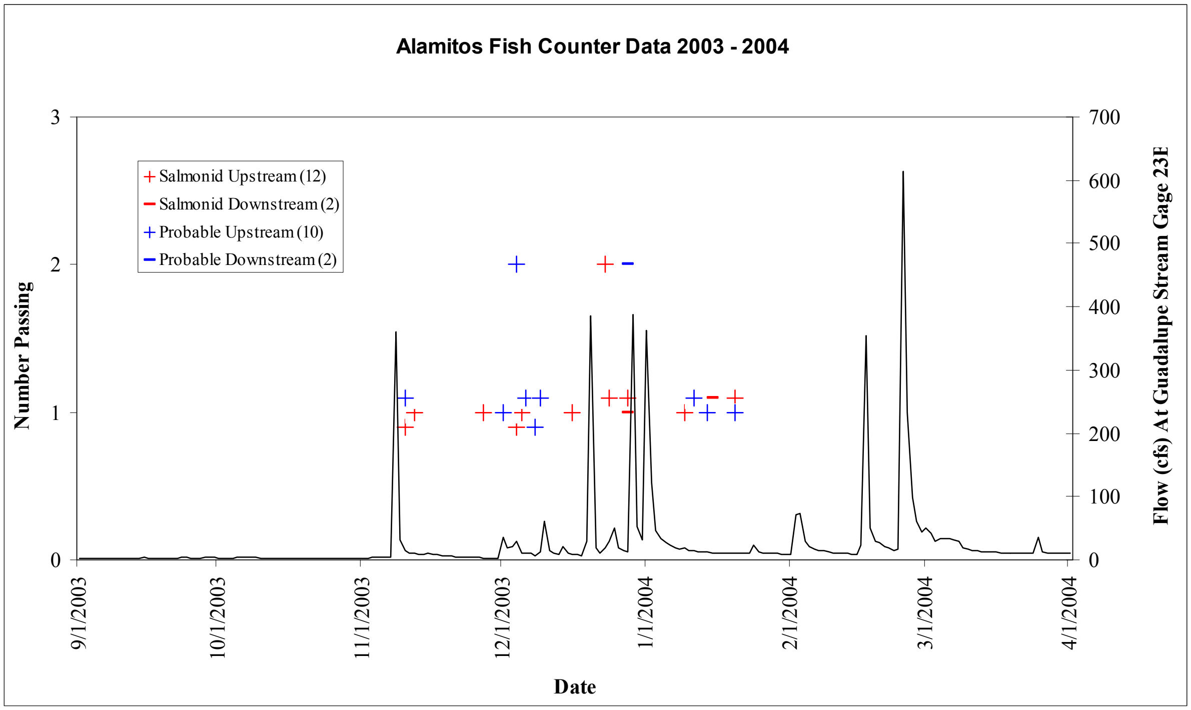

Figure 6. Salmonid passage at the fish counter vs. date and flow.

Other migratory patterns detected by the RW include those of the common carp, a species not typically identified as a strong jumper, which were able to negotiate the fish ladder. On September 15, 2003, when flow was restored to the fish ladder for the season, several carp were observed migrating immediately up the ladder. Once the RW became functional on September 19, 2003, approximately 30 carp migrated through the counting device the following day. Additionally in the spring, over 800 carp passed in schools both upstream (~ 460) and downstream (~ 374) through the counter between March 23 and April 8, 2004 (Figure 7). The entire time the RW was installed small numbers of carp continued to pass both up and down the ladder. Based on this year's data alone, it appears that carp are continuously on the move in this portion of the system. They seem to have a short upstream migrational period in the fall when the ladder opens and a peak in migration during the spring that is likely associated with their spawning season.

Ducks, bullfrogs, and turtles were either found holding in the fishway just upstream of the counting device, or were counted by the RW as they passed downstream. None of these animals appeared to use the fishway as a means for upstream passage.

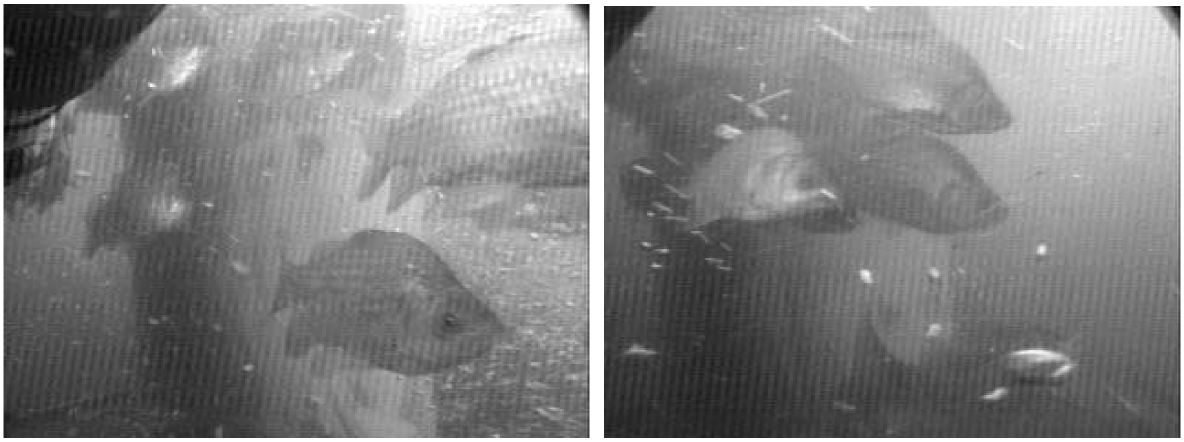

Figure 7. Spring migration of carp through the RW fish counter.

Temperature data was automatically collected every three hours by the RW (Figure 8). When the counter was installed in September, temperatures were 22°C. Temperatures remained consistently between 19 - 23°C until October 30, 2003, when they dropped one degree a day to level out at 16°C on November 1, 2003. Temperatures lingered between 15-16°C until November 21, 2003, when they suddenly dropped to less than 14 degrees. Temperatures remained between 12-14°C until December 5, 2003 when a warm spell increased temperatures to 15-16°C for one week and then again fell under 14°C. From this point on, temperatures stayed between 10 - 13°C until February 15, 2004 when they again increase to the 15°C range. From February 15 through March 7, 2004 temperatures fluctuated between 12 -15°C. After that date, temperatures ranged between 16 and 21°C until April 27, 2004 when temperatures hit 25°C. From late April through the end of the sampling in early July, temperatures ranged between 19 and 30°C.

The temperature probe accuracy on the RW was verified using an Onset Stowaway® temperature logger. The RW was accurate to within 0.5°C.

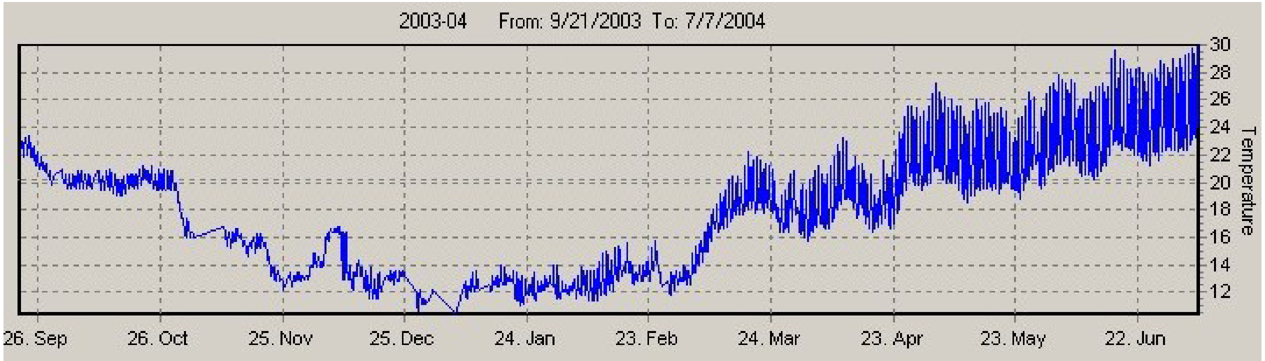

Figure 8. Temperature data from the RW fish counter.

Problems Encountered and Modifications Made

The RW was not a "turn-key" system; modifications to the system occurred on almost a weekly basis. The RW was installed for a total of 293 days and was not fully functional for 59 of the days during that period. Several times the counter malfunctioned, had software problems, or required modifications.

On October 2, 2003, the scanner plates malfunctioned when one side of the counter lost scanner visibility such that nothing would trigger the counter. The manufacturer deemed this to be a hardware error and shipped the District a set of new scanner plates. The plates arrived one week later and were installed on October 9, 2003.

Water clarity in the fish ladder was problematic almost the entire time the RW was operational. Algal blooms, turbidity, and clumps of vegetation created problems for acquiring clear photos of fish. The camera angle, its distance from the counter, camera light sources, reflective backgrounds, and camera quality were all issues throughout the year.

The digital photo portion of the RW was problematic for the entire 2003-04 season. A good quality, clear photo of an upmigrating salmonid was not obtained during this effort. The arm which held the camera in place was too long to capture clear images of fish due to the poor water clarity in the Guadalupe River. District staff fabricated a shorter camera arm to reduce the distance to the counter opening and improve the image quality of passing fish. Upon moving the camera closer, the field of view was sizably reduced and fish which swam high, low, or to either side were missed by the camera. To remedy this, a counter extension tube was fabricated and affixed to the counter to direct fish past the camera (Figure 9).

The camera functionality at night was very poor. Adding a white back drop helped to reflect some of the infrared light back to the camera. In March 2004, new LED lights were provided by Vaki and were installed to enhance nighttime photo-ability (Figure 9). This helped with color balance and clarity for both nighttime and daytime passage events.

The quality of the camera itself was also problematic. The image resolution at 640 x 480 is relatively poor quality when compared to current standards. The photo quality is grainy and when enlarged for fish identification purposes, the pixels enlarge and the image disintegrates. The manufacturer contends that modifications and new camera technology are being pursued.

Software problems with both the database program, "Winari," and the counter software, "Maricam" were numerous. Assistance was received from the manufacturer with software troubleshooting and received software upgrades several times throughout 2003-04.

During winter storms the “Maricam” software had problems sorting out migrating fish versus debris and turbulence due to increased flows in the ladder. Several storms caused the program to overload and falter, thus providing minimal to no data during high flow events.

Seventeen percent of the total records collected by the RW contained a software error in which passage events were documented but neither a silhouette nor a speed were recorded. Because the photo portion of the system worked so poorly, this software error effectively rendered the system useless during these periods. The manufacturer determined that the software problems were caused by too many error codes overloading the system in a short period of time. It was hypothesized that excess debris and turbulence could be overwhelming the system and accounting for these software errors. However, this year District staff has made extensive modifications and minimized debris and turbulence problems in the ladder, yet this software error is still a common occurrence. District staff contends that debris and turbulence are not the leading cause for this software error and this remains an outstanding issue with the manufacturer.

Another “Maricam” error occurred where the software mismatched photos with the wrong passage data such that photos looked to be taken during down rather than up passage events. Additionally, irregular error messages would appear on the counter computer which would not go away without rebooting the system. A new improved version of the “Maricam”software seemed to resolve both of these errors.

The “Winari” database program had several glitches with respect to settings, buttons, and export functions not working properly. The manufacturer sent several program patches and newer versions of the software to try and resolve these issues. To date, not all of these software problems have been solved and District fisheries staff is still working with Vaki to improve the system.

Several times during the winter season in late December 2003, the RW system shut down when the power source failed. The source of the problem was traced to low light and overcast weather conditions during which the solar panels were unable to recharge the two batteries which run the computer. The following month, two additional batteries were added to the power load and no power failures have occurred since.

Under high flow conditions in the fish ladder, those with greater than a 2 ft stage increase, the RW unit would overtop, allowing for fish passage to occur without being counted. In March 2004, District staff designed and installed some flow through panels to position on both sides of the counting unit. These new panels allowed high flows to dissipate easier at the counters location (Figure 9). However, the new weirs also created a vortex of bubbles which interfered with the camera visibility. A large plexi-glass panel was installed to act as a ‘bubble break’ and deter the bubbles from the cameras field of view.

Vaki Systems markets the RW product as being 95% accurate for fish over 40mm in depth. In January 2004, District staff tested the RW for size accuracy and sensitivity to different sized objects. Neutrally buoyant objects were attached to fishing line and pulled through the counter in both directions. Results showed that the counter was very effective recording passage of large objects (object sized 121 mm deep) yielding 90% accuracy , less effective for medium sized objects (67 mm in depth) with 65-80% accuracy, and rather ineffective for small objects (32 mm in depth) with less than 50% accuracy. The counter also failed to record more down than up hits. Given these size limitations, trying to enumerate outmigrating salmonid smolts is not currently possible with this system.

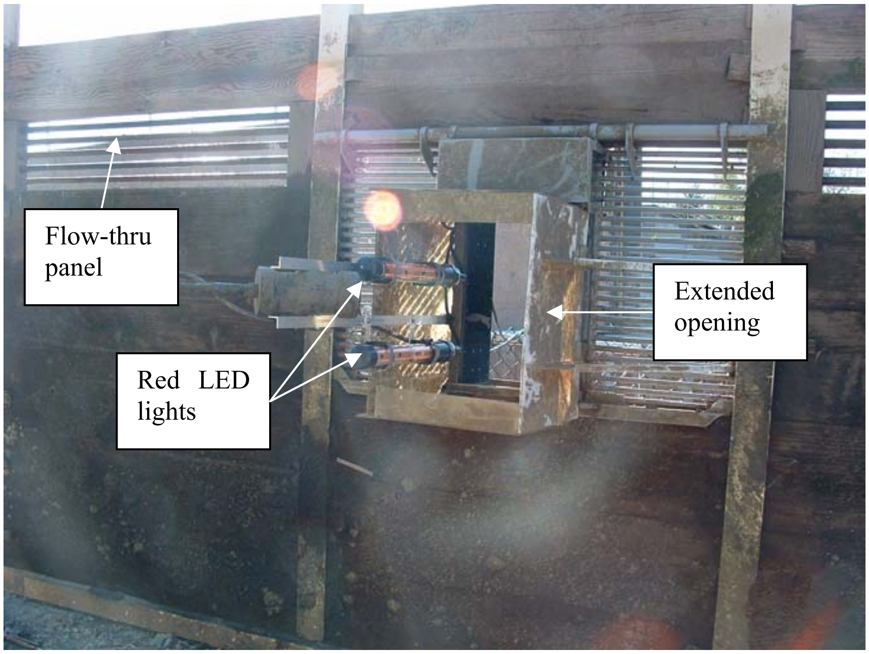

Figure 9. Modifications made to the RW.

IV. DISCUSSION

The fish counter had many limitations and problems to overcome during its first season. Several modifications were needed to enhance the function of the unit including, weir modifications, flow dissipating panels, additional batteries, an extended counter opening, a reflective backdrop, a bubble break, a shortened camera arm, brighter lights, and continual cleaning operations. Additionally, software modifications and upgrades throughout the 2003-04 season helped to improve the counters functionality.

Unfortunately, the RW still has several limitations which have not yet been overcome. The RW is not accurate for smaller fish and therefore, it is unlikely that outmigrating juvenile salmonids could be counted with this device. The camera quality is too poor to distinguish between adult Chinook salmon and steelhead/rainbow trout. Lastly, the “Maricam” software continues to have errors which are preventing District staff from getting a complete data set.

Given the sub-optimal performance of the fish counter, the District still was able to collect valuable information on fish passage through the Alamitos drop structure. Staff was able to determine the approximate number of adult salmonids which utilized the ladder and the timing of the adult salmonid migration into the upper watershed. Staff also determined that more than just salmonids are utilizing the ladder, other natives and non-natives not known for their acrobatic prowess such as Sacramento suckers, common carp and a variety of sunfish including largemouth bass were able to negotiate the ladder.

Further development of the hardware and software will be necessary for the 2004-05 seasons to improve the performance of the RW in the Alamitos fish ladder. District staff is optimistic that the manufacturer will continue to improve the system and provide camera, hardware, and software upgrades as they become available. Improvements planned for the 2004-05 fish counter season include installation of improved debris diversions upstream of the ladder to minimize debris flow through the counter, an elongated, tapered tube/funnel at the upstream exit of the counter to direct fish to swim in front of the camera, and another set of flow through panels on both sides of the counter to dissipate more flow and reduce both the whirlpool effect and excess bubbles which preclude the camera from taking optimum photos. Additionally, District staff is working with the manufacturer to devise an improved camera system that has better resolution, enhanced photo-ability at night, and takes pictures under low light and turbid conditions.

The Riverwatcher system has the potential to provide the District with valuable data regarding annual abundance, migrational timing, and the diversity of aquatic species utilizing the ladder. The benefits of this system could be immense if the device were to function properly under the environmental parameters here in the Santa Clara Valley. Additionally, since the counter is non-invasive and fish are afforded unobstructed passage, no permits are necessary from the Resource Agencies to run this system.